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L21: Entry 1 of 1 File: USPT Mar 7, 2000

DOCUMENT-IDENTIFIER: US 6034693 A
TITLE: Image synthesizing apparatus, image synthesizing method and information storage medium

Abstract Text (1):
An image synthesizing apparatus, an image synthesizing method and an information storage medium which can realize the representation of the front and back sides of a primitive surface while decreasing processing load. Whether the front or back side of a polygon (primitive surface) is to be displayed on a screen is judged. When the front side of the polygon is to be displayed, a first texture is mapped (on the polygon). On the other hand, if the back side of the polygon is to be displayed, a second texture is mapped (on the polygon). Thus, a realistic representation can be accomplished without increasing processing load. Depending on whether the front or back side of the polygon is to be displayed, various image information such as color palette, vertex brightness information, normal vector information lighting model parameter information and transparency information may be varied.

Brief Summary Text (5):
There are known many types of image synthesizing systems in which an object to be displayed is formed by polygons(primitive surfaces), such objects being used to synthesize an image. For example, in a three-dimensional racing game system, polygons are used to form other racing cars, guard-rails, signboards, roads, etc. to be displayed on a screen. A player operates its racing car using given operating means (steering wheel, accelerator pedal, game controller and others) for enjoying a car race with the other racing cars. In such an image synthesizing system, the viewpoint and sight line of the player vary depending on the operation of the player. This causes such a situation that the back side of the polygons will be displayed on the screen. Assuming a case that a signboard formed by polygons is to be displayed on the screen, the front side of the polygons is only displayed on the screen when a racing car on the screen goes forward. If the racing car on the screen goes backward, the back side of the polygons will be displayed.

Brief Summary Text (7):
On the other hand, another image synthesizing system of such a type that faces of a pair of polygons each used to form the back and front side of a signboard to be displayed are put together, raises another problem in that the number of polygons used to form an object is duplicated. Such an image synthesizing system is required to provide a real-time operation in which an image is synthesized in real time for the player's operation. When the number of polygons to be processed is increased, the processing load is correspondingly increased. Thus, the real-time operation will not be maintained, resulting in deterioration of the image quality.

Brief Summary Text (9):
In view of the aforementioned technical problems, the present invention is made and has its object to provide an image synthesizing apparatus, an image synthesizing method and an information storage medium which can be used to realize the display of front and back sides of primitive surfaces without increasing processing load so

much.

Brief Summary Text (10):
To this end, the present invention provides an image synthesizing apparatus for generating an image including objects each of which is formed by at least one primitive surface comprising:

Brief Summary Text (14):
The present invention also provides an image synthesizing apparatus for generating an image including objects each of which is formed by at least one primitive surface comprising:

Brief Summary Text (16):
means for forming an image of the primitive surface by referring to a first color palette through a color code when the front side thereof is to be displayed and for forming an image of the primitive surface by referring to a second color palette through a color code when the back side thereof is to be displayed.

Brief Summary Text (17):
According to the present invention, different color palettes are referred to form different images for the front and back sides of the primitive surface. Thus, a color which cannot be used to display the front side of the primitive surface may be used to display the back side of the primitive surface.

Brief Summary Text (18):
The present invention further provides an image synthesizing apparatus for generating an image including objects each of which is formed by at least one primitive surface comprising:

Brief Summary Text (20):
means for computing the brightness of the primitive surface by using at least one of vertex brightness information, normal vector information and lighting model parameter information and for varying the brightness information, the normal vector information and the lighting model parameter information depending on whether the front or back side of the primitive surface is to be displayed.

Brief Summary Text (22):
The present invention further provides an image synthesizing apparatus for generating an image including objects each of which is formed by at least one primitive surface comprising:

Brief Summary Text (24):
means for varying image information used to form an image of the primitive surface depending on whether the front or back side of the primitive surface is to be displayed. Thus, the front and back sides of an object can be represented with reality and without increasing the number of a primitive surface to be used. In such a case, it is desirable that the image information may be at least one of texture information, information for determining texture, color palette information, information for determining color palette, brightness information, information for determining brightness, transparency information and information for determining transparency.

Detailed Description Text (4):
FIG. 1 shows a view illustrating the principle of a first embodiment of the present invention. An object to be displayed 10 is formed by a plurality of polygons. Letters U and V represent coordinates in a texture plane. In this embodiment, for example, it is first judged whether the front or back side of a polygon 20 is to be displayed on a screen. If it is judged that the front side of the polygon is to be displayed, a first texture (texture for the front side) is mapped to the polygon 20. On the other hand, if it is judged that the back side of the polygon is to be

displayed, a second texture (texture for the back side) is mapped to the polygon 20. Thus, the front and back sides of the polygon can be realized by a single polygon without increasing processing load. On the contrary, in a system which the back side of a polygon cannot be displayed, the polygon will instantly vanishes when the polygon is reversed. It does not provide a sense of reality. In a system which faces of two polygons are put together to form both the front and back sides surface of the object, two polygons are required to form one surface with increase of the number of polygons to be processed, resulting in increase of processing load. On the contrary, this embodiment of the present invention can realize the realistic representation of the front and back surface of an object without increasing processing load.

Detailed Description Text (6):
Various techniques for judging the front and back sides of the polygon may be taken in the present invention. In a first technique, as shown in FIG. 3A, vertex numbers have been previously provided to the respective vertices of a polygon. The displayed face of the polygon is judged to be front or back side depending on whether these vertex numbers are sequentially followed anti-clockwise or clockwise. A second technique computes the vector product of the vertex coordinates in a polygon. The vector product is determined in respect to its plus or minus Z-coordinate. The result is used to judge the front or back side of the polygon. This corresponds to determination of the direction of the normal vector in the polygon surface. A third technique is such that if a moving body 22 manipulated by a player (whose viewpoint follows the moving body) is outside of a dome 24, it is judged that the polygon forming the dome 24 is the front side. Thus, the front side of the polygon is displayed. If the moving body 22 is inside of the dome 24, it is then judged that the polygon to be displayed is the back side. Thus, the back side of the polygon is displayed. In such a manner, a single polygon is only used to represent the dome 24 without putting faces of two polygons together.

Detailed Description Text (7):
The judgment of the front and back sides of the polygon is not limited to the aforementioned three techniques, but may be carried out through any of various other techniques. Although it is generally desirable that the texture information is color information such as color codes or the like, any other information such as translucent information, brightness information, surface shape information (e.g., normal vector information or displacement information), reflectance information, index of refraction information, depth information or the like can be applied.

Detailed Description Text (12):
FIG. 4 shows a view illustrating the principle of a second embodiment of the present invention. As in the first embodiment, the second embodiment judges whether the front or back side of a polygon is to be displayed on a screen. If it is judged that the front side of the polygon is to be displayed, a first color palette is referred to through a color code to form image information. More particularly, RGB information to be displayed at objective dots is determined. On the other hand, if it is judged that the back side of the polygon is to be displayed, a second color palette is referred to through a color code to form image information. In such a manner, different color palettes can be used for displaying back and front side of the polygon to be displayed. Thus, for example, the front side of the polygon may be more brightened while the back side of the polygon may be more darkened. Furthermore, colors that are represented by a combination of RGB but cannot be used on representation of the front side of the polygon can be used on representation of the back side of the same object. In FIG. 3B, for example, a polygon forming a dome 24 has the same color code both for the front and back sides thereof, but only a color palette is changed. More particularly, when a moving body 22 is to be moved into the dome 24 and if the back side of the polygon forming the dome 24 is to be displayed, a color palette for representing a more darkened color will be selected. Thus, the dome 24 having a specific color on its outer side may be represented with the more darkened color than the color specified for the outer side when the moving

body has entered into the dome 24. This provides a realistic representation without increasing processing load so much.

Detailed Description Text (17):
The third embodiment is such that depending on whether the front or back side of the polygon is to be displayed, at least one of vertex brightness information, normal vector information and lighting model parameter information all of which are used to compute the brightness of a polygon is varied.

Detailed Description Text (18):
With Gouraud shading, for example as shown in FIG. 6A, vertex brightness information Ia0, Ia1, Ia2 and Ia3 for displaying the front side of a polygon is different from vertex brightness information Ib0, Ib1, Ib2 and Ib3 for displaying the back side of a polygon. Thus, the brightness and shading of the polygon can be varied depending on whether the front or back side of the polygon is to be displayed. This can be accomplished with realistic representation without increasing processing load so much. Technique for varying the vertex brightness information may be provided by causing each polygon to have two types of vertex brightness information Ia0 to Ia3 and Ib0 to Ib3 as one of polygon information. It may also be provided by causing vertex brightness information IO to I3 as polygon information to be subjected to various computations, thereby obtaining the front and back side vertex brightness information Ia0 to Ia3 and Ib0 to Ib4, as shown in FIG. 6B. For example, addition of a predetermined value to I0 to I3 may generate Ia0 to Ia3 while subtraction of a predetermined value from I0 to I3 may generate Ib0 to Ib3. In such a case, the whole object may be brightened if the front side of the polygon is displayed while the whole object may be darkened if the back side thereof is displayed.

Detailed Description Text (19):
With Phong's smooth shading, for example, as shown in FIG. 6C, normal vector information na0, na1, na2 and na3 (or nac) for displaying the front side of a polygon is different from normal vector information nb0, nb1, nb2 and nb3 (or nbc) for displaying the back side of the polygon. This can also vary the brightness or shading of the polygon depending on whether the front or back side of the polygon is to be displayed. This can also be accomplished with realistic representation and without increasing processing load so much. Technique for varying the normal vector information may be provided by causing each polygon to have two types of normal vector information na0 to na3 (or nac) or nb0 to nb3 (or nbc) as polygon information. It may also be provided by causing normal vector information n0 to n3 (or nc) as polygon information to be subjected to various computations, thereby obtaining normal vector information na0 to na3 (or nac) and nb0 to nb3 (or nbc) for the front and back sides of the polygon, as shown in FIG. 6D.

Detailed Description Text (20):
When vertex brightness information is determined from normal vector information and if this vertex brightness information is used to perform the Gouraud shading process, the normal vector information may be varied depending on whether the front or back side of the polygon is to be displayed.

Detailed Description Text (21):
In place of or together with the vertex brightness information and normal vector information, lighting model parameter information may be varied.

Detailed Description Text (26):
In such a case, the amount of light incident on the surface of an material per unit area is proportional to COS .theta. if an angle included between a normal vector N and a light vector L on a plane of FIG. 7A is .theta.. If COS .theta. is minus, the amount of light is zero. If the length of the vectors N and L are equal to 1, COS .theta. can be represented by the dot product of the vector N and L, or N.multidot.L. This dot product N.multidot.L may be used to determine the

coefficient d of the diffuse component as follows:

Detailed Description Text (28):
Phong shading which uses a lighting model also using the specular component of the light will now be described. The specular reflection is observed on a surface. Since the surface of an material is rough, the specular reflection has a spread direction. The intensity of the specular reflection increases as an angle .beta. (an angle represented between vectors N and H) of FIG. 7B decreases.

Detailed Description Text (29):
H is equal to (E+L)/.vertline.E+L.vertline. and is a vector of which direction is half way between the vectors E and L. Since the specular reflection is generated at a portion of the material surface oriented toward the direction H, the intensity of the specular reflection depends on the dot product of the vector H and N. With Phong shading, the coefficients of the diffuse and specular components are represented as follows:

Detailed Description Text (30):
In the above formulae, it is premised that the length of all the vectors N, L and H is equal to 1. In the lower formula, by varying the value n, various ways of spreading the highlight can be obtained.

Detailed Description Text (32):
By varying the parameter information such as specular, ambient and diffuse components of the light, light vector and normal vector of the surface in the lighting model as described above, depending on whether the front or back side of the polygon is to be displayed, a single polygon can be used to display the front and back sides of the object with realistic representation.

Detailed Description Text (34):
The information storage medium 1006 mainly stores information such as image and sound information for representing objects to be displayed and may take any of various media such as CD-ROM, game cassette, IC card, DVD, MO, FD and memory. For example, the information storage medium such as CD-ROM, game cassette or DVD is used for a domestic game machine to store a game program and the like. With an arcade game machine, a memory such as ROM may be used. In such a case, the information storage medium 1006 may be the ROM 1002.

Detailed Description Text (40):
FIG. 12A shows an arcade game machine to which the first to third embodiments are applied. A player can enjoy a game by manipulating a lever 1102 and buttons 1104 and others while viewing a game picture displayed on a display 1100. An IC board 1106, which itself is included in the game machine, includes CPU, image synthesizing IC, sound synthesizing IC and others which are mounted therein. A memory 1108, which is an information storage medium on the IC board 1106, stores information used for such as judging whether the front or back side of the primitive surface is to be displayed, and information for varying image information used in forming the image of the primitive surface, depending on whether the front or back side of the primitive surface is to be displayed. The information will be referred to "the stored information". The stored information includes at least one of program codes used to perform the aforementioned processings, image information, sound information, shape information of objects to be displayed, table data, list data, player's information and other information.

Detailed Description Text (44):
In the first to third embodiments of the present invention, the texture for mapping, the color palette to be referred to, the brightness information or the like is varied depending on whether the front or back side of the primitive surface is to be displayed. However, the present invention is not limited to these embodiments, but it may be applied to such a configuration at least that the image

information used to form the image of a primitive surface is varied depending on whether the front or back side of the primitive surface is to be displayed. In this case, the image information may include various information such as texture information, information for determining texture, color palette information, information for determining color palette, brightness information, information for determining brightness, transparency information and information for determining transparency.

Detailed Description Text (47):
The present invention can synthesize various images. In the racing car game shown in FIG. 8A, for example, the signboard polygon 34 may be synthesized into a form as viewed from the racing car 30 and another form as viewed from the other racing car 32. As shown in FIGS. 8B and 8C, the front side of the signboard polygon 34 viewed from the racing car 30 may be displayed on a screen while the back side of the signboard polygon 34 viewed from the racing car 32 may be displayed on the screen. A Chinese restaurant guided by the signboard must be displayed with its front or back side thereof since this shop is in the straight direction from the racing car 30 and also in the turned direction from the racing car 32. According to the present invention, such a change between the front and back sides of the signboard in the viewed direction can be accomplished without increasing processing load so much since a single polygon is used to realize the front or back side of the polygon, as shown in FIGS. 8B and 8C. More particularly, it is judged that the front side of the signboard polygon 34 is to be displayed as it is viewed from the racing car 30. Thus, a front side texture is mapped on the sign board and a front side color palette is used. The brightness thereof is computed using a front side information. On the other hand, if the signboard polygon 34 is viewed from the racing car 32, it is judged that the back side of the signboard polygon 34 is to be displayed. Thus, a back side texture is mapped on the signboard polygon and a back color palette is used. The brightness thereof is also computed using a back side information.

Detailed Description Text (49):
Moreover, according to the present invention, the representation of such a water surface as shown in FIGS. 10A and 10B can be easily accomplished. FIG. 10A shows an image when the water surface is viewed from above, and FIG. 10B shows an image when the water surface is viewed from thereunder (or from the underwater). In such a case, it is desirable that the transparency in addition to the texture, color palette and brightness are varied. In other words, the transparency is decreased as the water surface is viewed from above while the transparency is increased as the water surface is viewed from under. Thus, the bottom of the water may be less viewed as the water surface is viewed from above. When the water surface is viewed from under, a tree located above the water surface may be displayed on the water surface. For example, if it is assumed that the color of a transparent (or translucent) object is C1 and the color of the background is C2, the whole color can be represented by C=tC2+(1-t)C1. The transparency may be varied by varying the above value t depending on whether the water surface is viewed from above or under. In order to provide a distorted image of the tree disturbed by waves, the normal vector information used to represent the condition of the waved surface may be varied depending on whether the water surface is viewed from above or under.

Detailed Description Text (50):
In addition, the present invention can represent various other representation such as an object projected onto a mirror or window glass, the color or nerves of a leaf different depending on whether the front or back side of that leaf is to be displayed, the internal structure of an object (e.g., the inside of a bonnet in a crushed car), the wings of an airplane, the front and back sides of one page in a book, a flag fluttered by the wind and a fan.

CLAIMS:

1. An image synthesizing apparatus for generating an image including objects, each of which is formed by at least one primitive surface, comprising:

judging means for judging whether the front or back side of said at least one primitive surface should be displayed on a screen; and

mapping means for mapping a first texture to said at least one primitive surface when the front side thereof is to be displayed and for mapping a second texture to said at least one primitive surface when the back side thereof is to be displayed.

3. The image synthesizing apparatus of claim 1, wherein the means for judging judges whether the front side or the back side of the primitive surface should be displayed based on at least one of:

vertex orientation information that identifies whether vertices of the primitive surface are oriented clockwise or counterclockwise, and

vector product information that identifies a vector product of vertex coordinates with respect to a positive or negative z-coordinate system.

4. An image synthesizing apparatus for generating an image including objects, each of which is formed by at least one primitive surface, comprising:

judging means for judging whether the front or back side of said at least one primitive surface should be displayed on a screen; and

forming means for forming an image of said at least one primitive surface by referring to a first color palette through a color code when the front side of said at least one primitive surface is to be displayed and for forming an image of said at least one primitive surface by referring to a second color palette through a color code when the back side of said at least one primitive surface is to be displayed.

6. The image synthesizing apparatus of claim 4, wherein the means for judging judges whether the front side or the back side of the primitive surface should be displayed based on at least one of:

vertex orientation information that identifies whether vertices of the primitive surface are oriented clockwise or counterclockwise, and

vector product information that identifies a vector product of vertex coordinates with respect to a positive or negative z-coordinate system.

7. An image synthesizing apparatus for generating an image including objects, each of which is formed by at least one primitive surface, comprising:

judging means for judging whether the front or back side of said at least one primitive surface should be displayed on a screen; and

computing means for computing the brightness of said at least one primitive surface by using at least one of vertex brightness information, normal vector information and lighting model parameter information and for varying said brightness information, said normal vector information and said lighting model parameter information depending on whether the front or back side of said at least one primitive surface is to be displayed.

9. The image synthesizing apparatus of claim 7, wherein the means for judging judges whether the front side or the back side of the primitive surface should be displayed based on at least one of:

vertex orientation information that identifies whether vertices of the primitive surface are oriented clockwise or counterclockwise, and

vector product information that identifies a vector product of vertex coordinates with respect to a positive or negative z-coordinate system.

10. An image synthesizing apparatus for generating an image including objects, each of which is formed by at least one primitive surface, comprising:

judging means for judging whether the front or back side of said at least one primitive surface should be displayed on a screen; and

means for varying image information used to form an image of said at least one primitive surface depending on whether the front or back side of said at least one primitive surface is to be displayed.

13. The image synthesizing apparatus of claim 10, wherein the means for judging judges whether the front side or the back side of the primitive surface should be displayed based on at least one of:

vertex orientation information that identifies whether vertices of the primitive surface are oriented clockwise or counterclockwise, and

vector product information that identifies a vector product of vertex coordinates with respect to a positive or negative z-coordinate system.

14. An image synthesizing method for generating an image including objects, each of which is formed by at least one primitive surface, comprising the steps of:

judging whether the front or back side of said at least one primitive surface is to be displayed on a screen; and

varying image information used to form the image of said at least one primitive surface depending on whether the front or back side of the at least one primitive surface is to be displayed.

18. An information storage medium for generating an image including objects, each of which is formed by at least one primitive surface, comprising:

information used to judge whether the front or back side of the at least one primitive surface is to be displayed on a screen; and

information used to vary image information used to form an image of said at least one primitive surface depending on whether the front or back side of the at least one primitive surface is to be displayed.

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Search Results - Record(s) 1 through 10 of 24 returned.

☐ 1. Document ID: US 20030052893 A1

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L30: Entry 1 of 24 File: PGPB Mar 20, 2003

PGPUB-DOCUMENT-NUMBER: 20030052893
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030052893 A1

TITLE: Coloring information adding method and apparatus, and image processing method and apparatus

PUBLICATION-DATE: March 20, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Sawada, Yasuhiro	Tochigi		JP	

US-CL-CURRENT: 345/589

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw. D

☐ 2. Document ID: US 20030025700 A1

L30: Entry 2 of 24 File: PGPB Feb 6, 2003

PGPUB-DOCUMENT-NUMBER: 20030025700
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030025700 A1

TITLE: Draw processing device and drawing method for drawing image on two-dimensional screen

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw. D

☐ 3. Document ID: US 20020196254 A1

L30: Entry 3 of 24 File: PGPB Dec 26, 2002

PGPUB-DOCUMENT-NUMBER: 20020196254
PGPUB-FILING-TYPE: new

DOCUMENT-IDENTIFIER: US 20020196254 A1

TITLE: Graphics processor and system for determining colors of the vertices of a figure

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☑ 4. Document ID: US 20020135603 A1

L30: Entry 4 of 24 File: PGPB Sep 26, 2002

PGPUB-DOCUMENT-NUMBER: 20020135603
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020135603 A1

TITLE: Image generation system and information storage medium

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 5. Document ID: US 20020106206 A1

L30: Entry 5 of 24 File: PGPB Aug 8, 2002

PGPUB-DOCUMENT-NUMBER: 20020106206
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020106206 A1

TITLE: Image-capturing device

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 6. Document ID: US 20020003630 A1

L30: Entry 6 of 24 File: PGPB Jan 10, 2002

PGPUB-DOCUMENT-NUMBER: 20020003630
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020003630 A1

TITLE: Image processing system

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 7. Document ID: US 6614555 B1

L30: Entry 7 of 24 File: USPT Sep 2, 2003

US-PAT-NO: 6614555
DOCUMENT-IDENTIFIER: US 6614555 B1

TITLE: Image processing apparatus and method for matching the color appearance between a material color and a light source color

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 8. Document ID: US 6549202 B1

L30: Entry 8 of 24 File: USPT Apr 15, 2003

US-PAT-NO: 6549202
DOCUMENT-IDENTIFIER: US 6549202 B1

TITLE: Rendering method and device, a game device, and a computer readable recording medium storing programs for rendering a three-dimensional model

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 9. Document ID: US 6388769 B1

L30: Entry 9 of 24 File: USPT May 14, 2002

US-PAT-NO: 6388769
DOCUMENT-IDENTIFIER: US 6388769 B1
** See image for Certificate of Correction **

TITLE: Luminance conversion of material color and light source color

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 10. Document ID: US 6373596 B1

L30: Entry 10 of 24 File: USPT Apr 16, 2002

US-PAT-NO: 6373596
DOCUMENT-IDENTIFIER: US 6373596 B1
** See image for Certificate of Correction **

TITLE: Luminance conversion of light source color into material color

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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Terms	Documents
"light source" with process$3 with calculat$3 with information with (color or brightness)	24

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